CLAIMS

What is claimed is:

1. A method, comprising:

generating an acoustic signal from an actuator of a first computing device;

receiving the acoustic signal with a sensor of a second computing device;

receiving the acoustic signal with a sensor of a third computing device;

generating an estimate of a difference between the amount of time required for the acoustic signal to travel from the actuator of the first computing device to the sensor of the second computing device and the amount of time required for the acoustic signal to travel from the actuator of the first computing device to the sensor of the third computing device, wherein the sensors and actuator are unsynchronized; and

computing, based on the estimated difference in time, a physical location of at least one of a set including the sensor of the third computing device, the sensor of the second computing device, and the actuator of the first computing device.

2. The method of claim 1, wherein the method further includes:

generating a second acoustic signal from an actuator of the second computing device;

receiving the acoustic signal with a sensor of the first computing device;

receiving the acoustic signal with a sensor of the third computing device;

generating a second estimate of a difference between the amount of time required for the acoustic signal to travel from the actuator of the second computing device to the sensor of the first computing device and the amount of time required for the acoustic signal to travel from the actuator of the second computing device to the sensor of the third computing device, wherein the sensors and actuators are unsynchronized; and

computing, based on the second estimated difference in time, a physical location of at least one of a set including the sensor of the third computing device, the sensor of the second computing device, the sensor of the first computing device, the actuator of the second computing device, and the actuator of the first computing device.

3. The method of claim 2, wherein the method further includes:

clustering the estimated locations of the actuator and sensor of each computing device to a single location; and

computing an initial estimation of the physical location of each computing device cluster that includes an actuator and a sensor via multidimensional scaling, prior to computing the physical location of at least one of a set including the sensor or actuator of the first computing device, the sensor or actuator of the second computing device, the sensor or actuator of the third computing device, and the sensor or actuator of the fourth computing device.

4. The method of claim 3, wherein the method further includes computing an estimation of the distance between two given computing device clusters, where the amount of time

required for an acoustic signal to travel between the two computing device clusters is unknown, by:

locating at least four common additional computing device clusters where the amount of time required for an acoustic signal to travel from each of the at least four additional clusters to each of the two given clusters is known;

estimating an amount of time required for an acoustic signal to travel between the two given clusters by utilizing the known acoustic travel times from each of the at least four common clusters to each of the two given clusters in a trilateration computation via multidimensional scaling.

5. The method of claim 3, further including:

estimating a systemic time delay for each computing device between the initial time a command was issued to capture the acoustic signal and the time when the acoustic signal was actually received via the sensor;

adding the estimated emitting time delay per device into the equation to compute the physical location.

6. The method of claim 5, further including:

computing a first non-linear least squares physical location estimation of an actuator or sensor on a given computing device by using as input a set of information including:

the estimated differences in time required for an acoustic signal to travel from the actuator of the given computing device to the sensors of two other discrete computing devices;

the initial estimate of the physical location of the given computing device via multidimensional scaling; and

the estimated receiving systemic time delays.

7. The method of claim 6, further including:

estimating a systemic time delay for each computing device between the initial time a command was issued to emit the acoustic signal and the time when the acoustic signal was actually emitted from the actuator; and

adding the estimated emitting time delay per device into the equation to compute the physical location.

8. The method of claim 7, further including:

computing a second non-linear least squares physical location estimation of the same actuator or sensor on a given computing device by using as input a set of information including:

the initial estimates of time required for an acoustic signal to travel from the given computing device actuator to all other known discrete computing device sensors;

the initial estimate of the physical location of the given computing device via multidimensional scaling; and

the estimated receiving and emitting systemic time delays.

9. The method of claim 8, further including:

computing the reliability percentage, using non-linear least squares, of the first and second computed physical locations; and

computing a final estimated physical location of the actuator or sensor by combining the first and second physical locations and weighting each location according to the computed reliability percentages.

10. The method of claim 9, wherein the acoustic signal is selected from a group comprising of maximum length sequence signal and a chirp signal.

11. The method of claim 1, wherein the method further includes:

receiving the acoustic signal with a sensor of a fourth computing device;

generating a second estimate of a difference between the amount of time required for the acoustic signal to travel from the actuator of the first computing device to the sensor of the fourth computing device and the amount of time required for the acoustic signal to travel from the actuator of the first computing device to the sensor of the second computing device, wherein the sensors and actuator are unsynchronized;

generating a third estimate of a difference between the amount of time required for the acoustic signal to travel from the actuator of the first computing device to the sensor of the fourth computing device and the amount of time required for the

acoustic signal to travel from the actuator of the first computing device to the sensor of the third computing device, wherein the sensors and actuator are unsynchronized; and

computing, based on the second and third estimated differences in time, a physical location of at least one of a set including the sensor of the fourth computing device, the sensor of the third computing device, the sensor of the second computing device, and the actuator of the first computing device.

12. A machine readable medium having embodied thereon instructions, which when executed by a machine, comprises:

generating an acoustic signal from an actuator of a first computing device;

receiving the acoustic signal with a sensor of a second computing device;

receiving the acoustic signal with a sensor of a third computing device;

generating an estimate of a difference between the amount of time required for the acoustic signal to travel from the actuator of the first computing device to the sensor of the second computing device and the amount of time required for the acoustic signal to travel from the actuator of the first computing device to the sensor of the third computing device, wherein the sensors and actuator are unsynchronized; and

computing, based on the estimated difference in time, a physical location of at least one of a set including the sensor of the third computing device, the sensor of the second computing device, and the actuator of the first computing device.

13. The machine readable medium of claim 12, wherein the machine readable medium further includes:

generating a second acoustic signal from an actuator of the second computing device;

receiving the acoustic signal with a sensor of the first computing device;

receiving the acoustic signal with a sensor of the third computing device;

generating a second estimate of a difference between the amount of time required for the acoustic signal to travel from the actuator of the second computing device to the sensor of the first computing device and the amount of time required for the acoustic signal to travel from the actuator of the second computing device to the sensor of the third computing device, wherein the sensors and actuators are unsynchronized; and

computing, based on the second estimated difference in time, a physical location of at least one of a set including the sensor of the third computing device, the sensor of the second computing device, the sensor of the first computing device, the actuator of the second computing device, and the actuator of the first computing device.

14. The machine readable medium of claim 13, wherein the machine readable medium further includes:

clustering the estimated locations of the actuator and sensor of each computing device to a single location; and

computing an initial estimation of the physical location of each computing device cluster that includes an actuator and a sensor via multidimensional scaling, prior to

computing the physical location of at least one of a set including the sensor or actuator of the first computing device, the sensor or actuator of the second computing device, the sensor or actuator of the third computing device, and the sensor or actuator of the fourth computing device.

15. The machine readable medium of claim 14, wherein the machine readable medium further includes computing an estimation of the distance between two given computing device clusters, where the amount of time required for an acoustic signal to travel between the two computing device clusters is unknown, by:

locating at least four common additional computing device clusters where the amount of time required for an acoustic signal to travel from each of the at least four additional clusters to each of the two given clusters is known;

estimating an amount of time required for an acoustic signal to travel between the two given clusters by utilizing the known acoustic travel times from each of the at least four common clusters to each of the two given clusters in a trilateration computation via multidimensional scaling.

16. The machine readable medium of claim 14, further including:

estimating a systemic time delay for each computing device between the initial time a command was issued to capture the acoustic signal and the time when the acoustic signal was actually received via the sensor;

adding the estimated emitting time delay per device into the equation to compute the physical location.

17. The machine readable medium of claim 16, further including:

computing a first non-linear least squares physical location estimation of an actuator or sensor on a given computing device by using as input a set of information including:

the estimated differences in time required for an acoustic signal to travel from the actuator of the given computing device to the sensors of two other discrete computing devices;

the initial estimate of the physical location of the given computing device via multidimensional scaling; and

the estimated receiving systemic time delays.

18. The machine readable medium of claim 17, further including:

estimating a systemic time delay for each computing device between the initial time a command was issued to emit the acoustic signal and the time when the acoustic signal was actually emitted from the actuator; and

adding the estimated emitting time delay per device into the equation to compute the physical location.

19. The machine readable medium of claim 18, further including:

computing a second non-linear least squares physical location estimation of the same actuator or sensor on a given computing device by using as input a set of information including:

the initial estimates of time required for an acoustic signal to travel from the given computing device actuator to all other known discrete computing device sensors;

the initial estimate of the physical location of the given computing device via multidimensional scaling; and

the estimated receiving and emitting systemic time delays.

20. The machine readable medium of claim 19, further including:

computing the reliability percentage, using non-linear least squares, of the first and second computed physical locations; and

computing a final estimated physical location of the actuator or sensor by combining the first and second physical locations and weighting each location according to the computed reliability percentages.

21. The machine readable medium of claim 20, wherein the acoustic signal is selected from a group comprising of maximum length sequence signal and a chirp signal.

22. The machine readable medium of claim 12, wherein the machine readable medium further includes:

receiving the acoustic signal with a sensor of a fourth computing device;

generating a second estimate of a difference between the amount of time required for the acoustic signal to travel from the actuator of the first computing device to the sensor of the fourth computing device and the amount of time required for the

acoustic signal to travel from the actuator of the first computing device to the sensor of the second computing device, wherein the sensors and actuator are unsynchronized;

generating a third estimate of a difference between the amount of time required for the acoustic signal to travel from the actuator of the first computing device to the sensor of the fourth computing device and the amount of time required for the acoustic signal to travel from the actuator of the first computing device to the sensor of the third computing device, wherein the sensors and actuator are unsynchronized; and

computing, based on the second and third estimated differences in time, a physical location of at least one of a set including the sensor of the fourth computing device, the sensor of the third computing device, the sensor of the second computing device, and the actuator of the first computing device.

23. A system, comprising:

a bus;

a processor coupled to the bus;

an audio device coupled to the bus with audio input and output capabilities; and memory coupled to the processor, the memory adapted for storing instructions, which upon execution by the processor generate an acoustic signal from an actuator of a first computing device, receive the acoustic signal with a sensor of a second computing device, receive the acoustic signal with a sensor of a third computing device, generate an estimate of a difference between the amount of time required for the acoustic signal to

travel from the actuator of the first computing device to the sensor of the second computing device and the amount of time required for the acoustic signal to travel from the actuator of the first computing device to the sensor of the third computing device, wherein the sensors and actuator are unsynchronized, and compute, based on the estimated difference in time, a physical location of at least one of a set including the sensor of the third computing device, the sensor of the second computing device, and the actuator of the first computing device.

24. The system of claim 23, wherein the system further includes:

generating a second acoustic signal from an actuator of the second computing device;

receiving the acoustic signal with a sensor of the first computing device;

receiving the acoustic signal with a sensor of the third computing device;

generating a second estimate of a difference between the amount of time required for the acoustic signal to travel from the actuator of the second computing device to the sensor of the first computing device and the amount of time required for the acoustic signal to travel from the actuator of the second computing device to the sensor of the third computing device, wherein the sensors and actuators are unsynchronized; and

computing, based on the second estimated difference in time, a physical location of at least one of a set including the sensor of the third computing device, the sensor of the second computing device, the sensor of the first computing device, the actuator of the second computing device, and the actuator of the first computing device.

25. The system of claim 24, wherein the system further includes:

clustering the estimated locations of the actuator and sensor of each computing device to a single location; and

computing an initial estimation of the physical location of each computing device cluster that includes an actuator and a sensor via multidimensional scaling, prior to computing the physical location of at least one of a set including the sensor or actuator of the first computing device, the sensor or actuator of the second computing device, the sensor or actuator of the third computing device, and the sensor or actuator of the fourth computing device.

26. The system of claim 25, wherein the system further includes computing an estimation of the distance between two given computing device clusters, where the amount of time required for an acoustic signal to travel between the two computing device clusters is unknown, by:

locating at least four common additional computing device clusters where the amount of time required for an acoustic signal to travel from each of the at least four additional clusters to each of the two given clusters is known;

estimating an amount of time required for an acoustic signal to travel between the two given clusters by utilizing the known acoustic travel times from each of the at least four common clusters to each of the two given clusters in a trilateration computation via multidimensional scaling.

27. The system of claim 25, further including:

estimating a systemic time delay for each computing device between the initial time a command was issued to capture the acoustic signal and the time when the acoustic signal was actually received via the sensor;

adding the estimated emitting time delay per device into the equation to compute the physical location.

28. The system of claim 27, further including:

computing a first non-linear least squares physical location estimation of an actuator or sensor on a given computing device by using as input a set of information including:

the estimated differences in time required for an acoustic signal to travel from the actuator of the given computing device to the sensors of two other discrete computing devices;

the initial estimate of the physical location of the given computing device via multidimensional scaling; and

the estimated receiving systemic time delays.

29. The system of claim 28, further including:

estimating a systemic time delay for each computing device between the initial time a command was issued to emit the acoustic signal and the time when the acoustic signal was actually emitted from the actuator; and

adding the estimated emitting time delay per device into the equation to compute the physical location.

30. The system of claim 29, further including:

computing a second non-linear least squares physical location estimation of the same actuator or sensor on a given computing device by using as input a set of information including:

the initial estimates of time required for an acoustic signal to travel from the given computing device actuator to all other known discrete computing device sensors;

the initial estimate of the physical location of the given computing device via multidimensional scaling; and

the estimated receiving and emitting systemic time delays.

31. The system of claim 30, further including:

computing the reliability percentage, using non-linear least squares, of the first and second computed physical locations; and

computing a final estimated physical location of the actuator or sensor by combining the first and second physical locations and weighting each location according to the computed reliability percentages.

32. The system of claim 31, wherein the acoustic signal is selected from a group comprising of maximum length sequence signal and a chirp signal.

33. The system of claim 23, wherein the system further includes:

receiving the acoustic signal with a sensor of a fourth computing device;

generating a second estimate of a difference between the amount of time required for the acoustic signal to travel from the actuator of the first computing device to the sensor of the fourth computing device and the amount of time required for the acoustic signal to travel from the actuator of the first computing device to the sensor of the second computing device, wherein the sensors and actuator are unsynchronized;

generating a third estimate of a difference between the amount of time required for the acoustic signal to travel from the actuator of the first computing device to the sensor of the fourth computing device and the amount of time required for the acoustic signal to travel from the actuator of the first computing device to the sensor of the third computing device, wherein the sensors and actuator are unsynchronized; and

computing, based on the second and third estimated differences in time, a physical location of at least one of a set including the sensor of the fourth computing device, the sensor of the third computing device, the sensor of the second computing device, and the actuator of the first computing device.

34. The system of claim 23, wherein the actuator is a speaker.

35. The system of claim 23, wherein the sensor is a microphone.